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Bandwidth Enrichment for Micro-strip Patch Antenna Using Pendant Techniques

D. Bhattacharya, R. Prasanna

School of Electrical Engineering, Vel Tech Dr. RR & Dr. SR Technical University

1. elec.research@yahoo.com, 2. prasannaram88@gmail.com

Abstract— ***A probe feed, slotted hexagonal patch antenna has been proposed. Bandwidth enhancement has been improved by suitably cutting slots into hexagonal patch. Proposed antenna is suitable for various telecoms, LAN, Wi-Fi applications in ISM-band. It is demonstrated that the proposed antenna exhibits resonance in ISM-Band and a peak gain of 6dBi.The antenna structure is described and simulated results are presented.***

Keywords—Microstrip patch antenna,Band width enhancement, Gain, Dielectric substrate,simulation.

I. Introduction

In rapidly expanding market for wireless communication and applications, Micro strip antenna has become widely popular as it is low profile, comfortable to the hosting surfaces, light weight and can be easily integrated with the electronic circuits. Microstrip antenna is widely used in military, mobile communication, global positioning system (GPS), remote sensing etc.

Taking benefits of added processing power of today's computers HFSS (High Frequency Structure Simulator) simulator are emerging to perform planer and 3D analysis of high frequency structure. HFSS simulator has long been an essential modeling tool for RF/Microwave design. Proposed antenna is designed and simulated on HFSS simulator software.

Microstrip patch antenna in general consists of a radiating conducting patch printed on a grounded dielectric substrate. The patch is a very thin metal disk. To overcome its limitation of narrow bandwidth by generating more than one resonant frequencies, many techniques have been suggested in the past e.g. different shaped slots[2-4],stack, multilayer[6],two folded parts to the main radiated patch and use of air substrate have been proposed and investigated. In the design presented in this paper slotting of the radiating patch has been used because as compared to the other techniques slotting offers the promise of saving space while giving good performance if done appropriately.

The advantages of microstrip antenna have made them a perfect candidate for use in the wireless local area network (WLAN) applications. Though bound by certain disadvantages microstrip patch antenna can be tailored so they can be used in the new high speed broadband WLAN system. This paper concentrates on manufacture of broadband micro strip patch antennas for 2.4GHz ISM –band.

It is now both possible and affordable to surf the web from your laptop without any wire connectivity and while enjoying cricket match on your television. A WLAN is a flexible data communication network used as an extension to or an alternative for a wired LAN in a building.

As a result the demand has been increased for broad band WLAN antenna that meets all the desired requirements. The broadband antenna are required to be compact, low profile directive for high transmission efficiency and designed to be discreet, due to these well met requirements couple with the ease of manufacture and repeatability makes the micro strip patch antennas very well suited for broadband wireless applications.

II. Antenna Geometry and Design Procedure

A microstrip patch antenna is a radiating patch on one side of a dielectric substrate which has a ground plane underside (fig1). The EM wave fringe off the top patch of the substrate, reflecting off the ground plane and radiates out into the air. Radiation occurs mostly due to the fringing field between the patch and ground. The radiation efficiency of the patch antenna depends

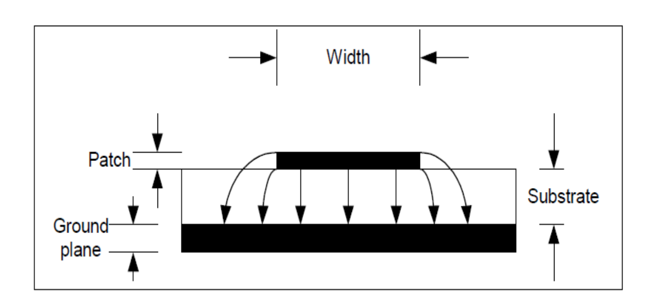


Fig1:- microstrip patch antenna

largely on the permittivity of the dielectric (ε). Ideally, a thick dielectric, low ε and low insertion loss is preferred for broadband purpose and increased efficiency. As shown in fig2 the antenna has hexagonal patch structure. The dielectric chosen is FR4-epoxy substrate having relative permittivity of 4.4 and the thickness of 1.53mm. The dimension of patch is approximated by using basic design approach described for microstrip patch antenna as listed below.

WIDTH OF PATCH

$$W = \frac{c}{2 f_0 \sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

EFFECTIVE DIELECTRIC CONSTANT

$$\varepsilon_{r_{eff}} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

EFFECTIVE LENGTH

$$L_{eff} = \frac{c}{2 f_0 \sqrt{\varepsilon_{reff}}}$$

LENGTH EXTENTION

$$\Delta L = 0.412h \frac{(\varepsilon_{reff} + 0.3)\left(\frac{w}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{w}{h} + 0.8\right)}$$

ACTUAL LENGTH OF PATCH

$$L = L_{eff} - 2\Delta L$$

Where;
$c = 3\text{x}10^{18}$ m/s.
h = height of substrate.
ε_r = dielectric constant of the substrate

This is the proposed antenna geometry having two slots of length l and width d is designed on the top of the hexagonal patch. The slot antenna is excited by coaxial probe feed which is situated at 45 degree of x-y plane.

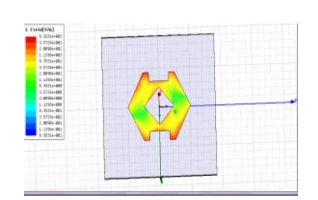


Fig2:-Main design with hexagonal patch

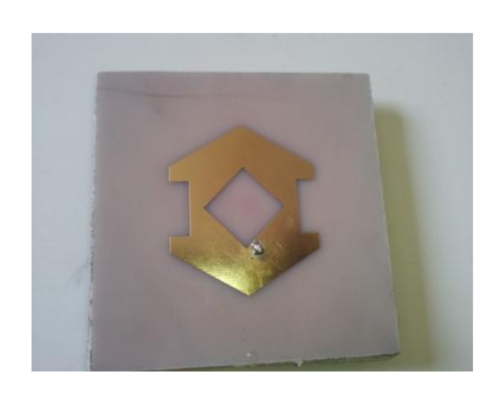
III SIMULATION SETUP

The proposed antenna is has been modeled by HFSS 11 simulator software. My primary use of the ANSOFT HFSS software is to design and simulate electrically small antennas.

The patch antenna is created by three bricks: First for the radiating plate second for the coaxial probe feed and third for the substrate. The ground plane is specified by a perfect electrically conducting boundary condition. The coordinates are assigned as follows. The starting point for the ground plane is (-25,-25, 0) and for the substrate is (-25,-25, 0.1). The length L of the substrate and the width are chosen as 50mm and 50mm respectively. Patch is the half that of the ground and substrate is equal to the length ~λ0/2 ~12.45 mm and the width of the patch is half that of the ground and substrate = 25mm. However, the patch's starting point is at (15, 0, 1.63). The patch's starting point is located at of the total width of the ground plane and stretches its length 12.45 mm in the positive x-direction. Moreover, the feed should be located somewhere between the values of the starting point and ending point of the patch. Although the feed is located at the midpoint, we have to shift the feed a little to the upper or lower side to achieve impedance matching.

Drawing the Model

Drawing the model would now be easy. All we have to do is to fill in the coordinates.



The 3D capabilities of HFSS make it an ideal candidate for this purpose, since the entire fine geometrical and electrical details of the antennas can be included in the solver. From my prior experience, this leads to a very accurate reproduction of the simulated performance in the experimental testing, thus avoiding costly re-makes of the fabricated prototypes. Furthermore, the ability to visualize the different field quantities within the solved designs, in conjunction with the HFSS fields calculator, greatly assists in the initial design of antennas. The Finite Element Method allows the user much better than other Methods to model any arbitrary shaped 3D structure. The HFSS tetrahedron mesh represents accurately even curved surfaces and highly detailed models. By using an adaptive meshing process the results may be obtained to user-specified accuracy with no engineering effort or manual intervention with the mesh process. This is particularly important because the engineer does not have to be familiar with the process of creating a mesh and does not need to put a higher amount of effort into the mesh creation. This process has repeatedly proven to be of significantly greater accuracy than non-adaptive solution processes and saves a tremendous amount of engineering time dependent characteristics. A number of frequency dependent material models are available.

First, let's start by drawing the ground plane by referring to the coordinates of the Ground Plane,

Second, let's draw the substrate. The substrate has the same dimensions of the ground plane.
Third, we create the patch. Knowing that the patch should be in the center, the coordinates are easy to calculate from the ground and substrate dimensions.
Fourth, create the microstrip feed. The microstrip feed position is chosen somewhere between the ends of the patch. In reality it should be at the middle, however, it is shifted more to one side of the patch for impedance matching purposes.
Assign Boundary:-

Now the model has been created, we need to assign boundary conditions. In HFSS, radiation boundaries are used to simulate open problems that allow waves to radiate infinitely far into space. HFSS absorbs the wave at the radiation boundary. The boundary condition should satisfy a certain distance from the antenna. Normally, its value is chosen between λ/8 to λ/12, where λ is calculated from λ=C/F, where c is 3 x 108 m/s and f is the frequency in (Hz).

Assign Excitation:-
Having the entire model set now, the only missing part is the excitation. The excitation is a sheet which is at the end point of feed. The Antennas are excited through the wave port. We need to create the wave sheet.

IV. SIMULATION RESULT AND DISCUSSION

The proposed antenna is had been modeled at the design frequency of 2.8GHz.It can be seen that the axial ratio in the broadside direction is below 3 db throughout a bandwidth of around 8MHz.The required axial ratio has been calculated using formula given below.

$$AR(dB) = 20\log\frac{E_R + E_L}{E_R - E_L}$$

The proposed antenna posses an average gain of 6db.return loss is around -17db.

Return loss:- a good antenna might have a value of -10db return loss as 90% of signal is absorbed and 10% is reflected back.the proposed antenna is giving the exelent return loss in s-band.the curve has a deep curve at centre frequency 2.85GHz.

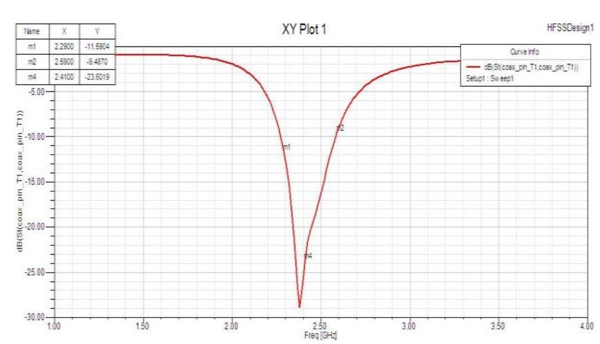


Fig3:-Return loss of proposed patch antenna

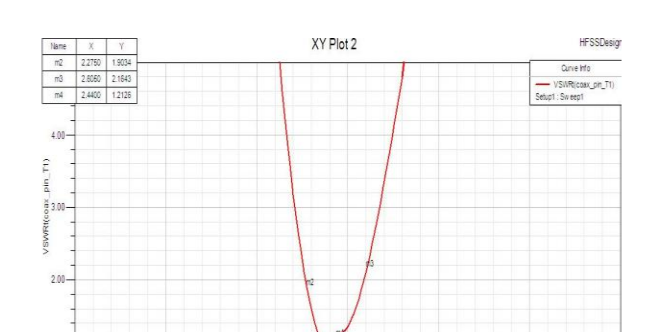


Fig4:-Axial ratio of proposed antenna

The axial ratio of the antenna is showing good circular polarization which is of 1dBi.fig4 shows the simulated axial ratio vs frequency graph.

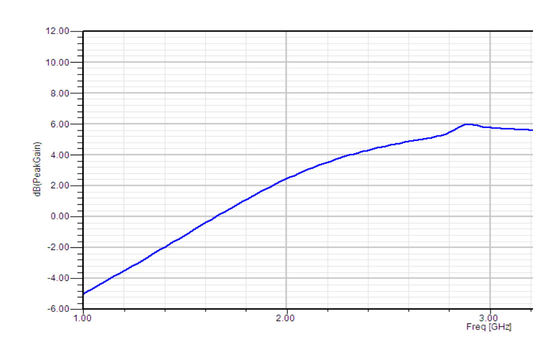


Fig5:Peak gain of proposed antenna

The peak gain of the antenna measured at resonating frequency points by comparison method. Figure.5 shows the measured antenna gain versus frequency where as 2.8GHz frequency band is approximately 6dBi.

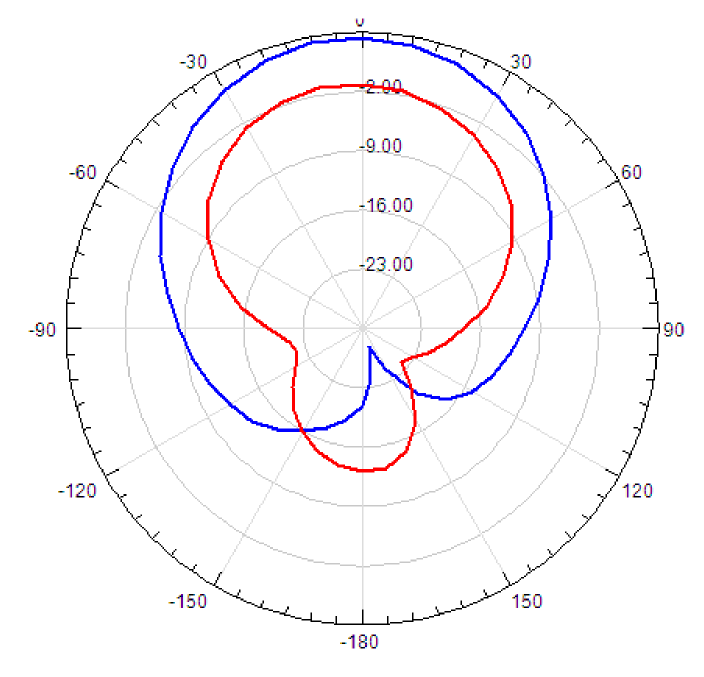


Fig6:-Radiation pattern of proposed antenna

Sr.No.	Antenna Parameters	Simulated	Measured
1.	Frequency Range	2.27GHz-2.59Ghz	2.26GHz-2.56GHz
2.	Return loss	-23.6dB	-22.2dB
3.	VSWR	1.21	1.41
4.	Bandwidth	320MHz	300MHz

The simulated and measured radiation patterns of the proposed antenna operating at 2.4GHz are shown in figure6. It is found that the antenna has relatively stable radiation patterns over its operating band; a near Omni directional pattern is obtained

III. CONCLUSION

With the help of HFSS11 software simulator a wideband and high gain CP-MSP antenna is designed. Slots are incorporated on hexagonal patch side. It can be fabricated and analyzed further due to simple structure. The antenna is successfully matches the desired characteristic of return loss less than -10db, axial ratio less than -3db, and peak gain of 6dbi.The simulated result shows that antenna exhibits good electrical performance and thus can be considered as a suitable candidate for various applications in ISM-band. Hence the proposed antenna is suitable for wireless local area network (WLAN) and multichannel multipoint distribution service (MMDS) WiMAX communication applications.

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Dr. Debmalya Bhattacharya is working as Associate Professor in Vel Tech Technical University Chennai. He has published several papers on DSP & Wireless communication in National and International Journals. His current research interests are DSP, Antenna Design & Wireless Communications and Renewable Energy Sources.



R.Prasanna finished his BE (ECE) in Adhiparasakthi engineering college and ME (Applied Electronics) in SSN college of engineering. Currently working as Assistant Professor in VEL TECH University Chennai.